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Towards Computerization of TB Care at Kibong'oto National TB Hospital in Tanzania

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Abstract: Tuberculosis (TB) continues to pose a global threat that causes millions of deaths globally annually. Several clinical Hospital Management Information Systems (HMIS) have been developed as well as specialized e-health systems to support TB care. However, most lead to isolation of patient's TB care data from other clinical data. At Kibong'oto Infectious Diseases Hospital (KIDH) in Tanzania, the HMIS named Care2x is also missing a module to support TB care, making the facility to use paper-based system in TB care. This study employed questionnaires, interviews, TB care documentation and Care2x system reviews to get what is required of the TB care computerization at KIDH. Responses from a total of 44 health practitioners and 2 Information Technology (IT) personnel were collected and analyzed. Findings indicate that an integration of all patient's data with TB care data is essential. This paper therefore, provides a design of a TB module for integrating in the existing Care2x HMIS at KIDH to improve delivery of health care to TB patients with timely and accurate reports generation as per World Health Organization (WHO) specifications.

Keywords: E-health, Care2x, TB care, Kibong'oto.

1. Introduction

Tuberculosis (TB) is observed to continue to be among the major causes of deaths globally with poorest communities being the most affected. There are millions of new cases and more than a million deaths worldwide yearly attributed to TB. In 2015, 1.8 million deaths and 1.7 million deaths occurred in 2016 (Falzon *et al.*, 2016; WHO, 2018). As per World Health Organization (WHO), TB prevalence is still high in Tanzania with 306 incidences out of 100,000 population as reported in 2015 (WHO, 2017). With proper medication and care, majority of TB cases may get cured (Falzon *et al.*, 2015).

To support the global TB burden, WHO has a strategy to end TB worldwide by 2035, the Stop TB Strategy, which recommends the use of electronic data recording and reporting (R&R) (Perumal and Desai, 2014; Kigozi *et al.*, 2017). WHO believes that information and communication technologies (ICTs) present innovation opportunities to support efforts in TB care and prevention (Falzon *et al.*, 2016). To succeed, this strategy depends much on R&R system used in TB surveillance (Nadol *et al.*, 2008). Many countries run control programs to support this strategy and some have implemented e-health systems to manage information in those programs (Konduri *et al.*, 2017). These systems help to integrate primary care (*by which practitioners record routine clinical patients' data to the systems*) with public health practices by analyzing data and producing real time reports and indicators for diseases to public health departments for policies creation and planning (Klompas *et al.*, 2012).

WHO defines e-health as use of ICTs to ensure timely provision of correct health information when that information is needed and to the ones needing it, securely and in electronic form, for improved quality and efficiency in healthcare delivery and prevention programs (WHO | eHealth, 2017). Several e-health systems that are clinical in focus have been implemented to transform medical care by increasing the safety, quality, and efficiency in handling patients' clinical data (Kukafka *et al.*, 2007; Klompas *et al.*, 2012). On the other hand, specialized e-health systems for diseases, which some have national control programs (such as TB) that require more than a generic e-health system have also been developed (Konduri *et al.*, 2017).

Tanzania has designated Kibong'oto Infectious Diseases Hospital (KIDH), formally Kibong'oto National TB Hospital (KNTH) to provide care and treatment of TB patients. It became a national TB hospital in 1956 and in 2010 KNTH received approval from the WHO to treat Multi-drug Resistant TB (MDR-TB) patients (stoptb.org, 2014). However, at KIDH, the Hospital Management Information System (HMIS)

in use, Care2x, maintains clinical information for patients but does not have a module to support TB care, making TB data for respective patients under TB care to be recorded in special paper forms provided by the Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC). Therefore, this paper focuses on assessing the current situation by analyzing the users' requirements for computerization of TB care at KIDH.

1.1 HMIS Implementations in Tanzania

Care2x HMIS: Care2x is a web-based open source cross platform and modular integrated HMIS which started as a sourceforge project in May 2002, and it was named care 2002 (Bouidi, Idrissi and Rais, 2017). The system is written in PHP, Java, JavaScript runs in Apache web server with MySQL backend database for storing data. It has among other, modules for Registration and Admission, Doctors, Nursing, Laboratory, Radiology, Billing, Pharmacy and Care and Treatment Clinic (CTC) (Care2X.org, 2018). The system being open source, it is being customized to meet the requirements for Tanzania hospitals. The Lutheran Investment Company (LUICo) owned by the Evangelical Lutheran Church in Tanzania (ELCT) is the one currently maintaining and customizing the system in Tanzania (ELCT, 2018).

Several other HMIS have been implemented in Tanzania. These include OpenMRS, Government of Tanzania HMIS (GoT-HOMIS), Powerweb's Hospital Management Software, MediPro e-Health and AfyaPro (Tierney *et al.*, 2010).

OpenMRS is open source software that was formed in 2004 for developing countries. It is customizable as per health provider needs without knowledge of programming required (Kalogiropoulos *et al.*, 2009). OpenMRS was implemented in 3 sites in Tanzania in the year 2008, the sites being Morogoro Regional Hospital which is a referral hospital in Morogoro region, Tumbi Special Hospital, a district hospital in Coast region and Ocean Road Cancer Institute in Dar Es Salaam. This implementation meant to eliminate paper based HIV-register forms by providing the National AIDS Control Program (NACP) with a database for HIV/AIDS registry (Tierney *et al.*, 2010).

On the other hand, GoT-HOMIS which is owned by the Regional Administration and Local Government of the Government of Tanzania has been implemented in over 170 facilities. An overview of this software's modules shows that it doesn't have a module for TB care (PO-RALG, 2017). Also, Powerweb's HMS is owned by an Information Technology (IT) company operating in Tanzania known as PowerComputers Telecommunications Ltd, thus, not free to customize (Powercomputers, 2017). Furthermore, MediPro e-Health developed by Maxcom Africa PLC is a modular system based on J2EE standard driven architecture and is platform and database independent (Maxcom Africa PLC-Maxmalipo, 2018). AfyaPro is also a HMIS that has core modules of registration, billing, inventory, diagnosis & treatment, laboratory, RCH, in-patient and CTC. The implementation of AfyaPro focused on Lake Zone regions in Tanzania. All these implementations however, do not mention to include integrated module for TB care (Afya Connect for Change, 2015).

1.2 Related Works

1.2.1 E-Health and TB Care in Developed Countries

To enhance national TB surveillance, United States of America (USA) implemented in March 2010 a web-based system called TB Genotyping Information Management System (TB GIMS). The system provides online secured database of TB data integrated with genotype results for TB programs at all levels, local and state (Ghosh *et al.*, 2012).

A web-based system called Tuberculosis Information Management System (TBIMS) was also implemented in China and started to phase out the paper recording of TB surveillance data in 2005 (Huang *et al.*, 2014). The system however focuses only on TB data recording and reporting.

1.2.2 E-Health and TB Care in Developing Countries

Nadol *et al.*, (2008) analyzed three systems, electronic tuberculosis register (ETR.Net), Electronic Nominal TB Registration System (ENRS) and eDOTS which was piloted tested in Uganda, Kenya, Kyrgyzstan, Mexico, Micronesia and Vietnam. ETR.Net was tested in South Africa, Botswana and Tanzania. It is based on Microsoft .Net framework and uses Microsoft Access and SQL server. An evaluation of ETR.Net in Eden District, South Africa, shows that it is simple and acceptable proved success to support the TB control program and reduced the incomplete data problem which existed in TB cards (Mlotshwa *et al.*, 2017). Moreover, ENRS was tested in Egypt, Jordan, Sudan and Syria. It is Microsoft Excel based. The two systems ETR.Net and ENRS do not eliminate the primary patient

forms used for maintaining patients' data at the lowest level. eDOTS however, supports patient-level data entry, data transfer to central computer as well as reports generations at different levels but it is proprietary with associated fees. Its interface is Microsoft Windows based and no communication with the HMIS (Nadol *et al.*, 2008).

Furthermore, Fraser *et al.*, (2013) developed OpenMRS-TB, an open source Electronic Medical Records (EMR) system implemented in Peru, Pakistan, Haiti and other areas with resource constraints. The system support MDR-TB data management and is also flexible to support other diseases.

In 2012, an android based system named Treatment Information from Basic Unit (TIBU) was deployed in Kenya to replace paper TB data R&R. The system synchronizes data with the national server through local data service providers. The data can be analyzed for reporting then. Despite proving success for TB surveillance in Kenya, the system has focus on TB only and doesn't solve the problem of patients' clinical data integration with TB data at facility level (Sharma *et al.*, 2015; Sitienei, 2016).

Also, in 2010, Lighthouse Trust and partners developed an EMR system that replaced the paper-based registers for TB and integrated with human immunodeficiency virus (HIV) antiretroviral therapy (ART) EMR at Martin Preuss Centre (MPC) clinic in Malawi (Tweya *et al.*, 2016). The system is open source. It led to improved patient care, however focuses only on the two care services, TB and HIV care (Tweya *et al.*, 2016).

Another major implementation of TB e-health system in more than ten countries, funded by USAID is the e-TB Manager. It was done in countries in East, South and West Africa, Central and South Asia, the Caribbean and Latin America. The system integrates all aspects of data in TB control required for TB control programs nationwide (Konduri *et al.*, 2017). Ukraine started to use e-TB Manager in 2009 and is one of the successful implementations nationwide (Konduri, Sawyer and Nizova, 2017).

In addition to that, Pellison *et al.*, (2017) in a project called ecosystem explain how tedious it is to organize patients' information to obtain complete history from different systems and TB data for better treatment strategies. They worked to integrate data in different systems to have a single, complete database that is well organized to provide quality information for TB patients that will be piloted in a state hospital of the São Paulo, Brazil (Pellison *et al.*, 2017).

Majority of reviewed implementations indicate isolation of patients' TB care data from other clinical data. This study therefore focused on providing a solution that will computerize TB care while focusing on integrating all patients' data.

2. Materials and Methods

2.1 The Research Study Area

This research selected KIDH located at 3°11'46.3"S 37°06'21.0"E coordinates in Siha district of Kilimanjaro Region, Tanzania. The targeted group was health services providers for TB patients.

2.2 Sampling

In conducting this study, purposive sampling was used to select KIDH since it is the facility specialized in TB care and designated to treat TB in the country. The facility has a total 250 employees, clinical and non-clinical. The numbers are as shown in Table 1.

Table 1: Number of Employees at Kibong'oto National TB Hospital as of May 2018

Title	Count	Title	Count
Doctors	21	Laboratory Personnel	11
Nurses	65	Radiologists	2
Medical Attendants	110	Pharmacists	5
IT personnel	2	Others	34
Total			250

From different employees' groups as shown in Table 1, stratified sampling was employed to get participants from different strata based on profession. On each stratum, representatives were selected randomly of which each had an equal chance. The selected representatives comprised of 12 doctors, 26 nurses, 3 laboratory personnel, 1 radiologist, 2 pharmacists and 2 IT personnel.

2.3 Data Collection Methods

Collection of data from the study area was conducted in May 2018. The tools and techniques employed in the collection of data were questionnaires, interviews as well as documents and Care2x system review. The tools and techniques are described below:

Questionnaires: The selected representatives were issued questionnaires with questions based on their profession, and some general questions to all. Questions focused on the current situation, the workflow of activities in TB patients' care with the associated tools, challenges faced on care giving and suggestions on what can be done.

Interviews: Some of the selected representatives along with filling the questionnaires, were also interviewed. Each stratum had at least one representative. The interviews focused on getting clarity on some medical terms and procedures involved in TB patients' care that require computerization.

Documents Review: Documentary analysis was done on all the provided paper work involved in TB care and treatment. The objective was to get all the required TB data elements that needed to be captured for computerization, and the associated required reports.

Care2x HMIS Review: A review of the existing Care2x system was done which focused on understanding the system architecture, design and functionalities.

2.4 Data Analysis

Qualitative and quantitative methods were both employed in this study to get what is required of the TB care computerization at KIDH. In analyzing quantitative results, the Statistical Package for the Social Sciences (SPSS) was used.

3. Results

3.1 Qualitative and Quantitative Results

All 46 questionnaires issued were filled by the participants (100% response). It was clear from the responses that the patient flow of TB patients is not different from other patients. The flow starts from registration then to consultation rooms, laboratory (if tests are requested), and pharmacy and then discharged. If a patient is admitted to Inpatient Department (IPD), he/she will be allocated to ward. After treatment, a patient will be discharged. Majority of respondents provided an understanding of the same workflow.

In attending TB patients, the following paper works are produced which need computerization: Patient TB register, patient file, patient laboratory request form, laboratory registers, patients' monitoring sheet/treatment card and adverse drug effects. All respondents (100%) indicated a need for the computerization of TB care. The main reason given by majority of respondents was to simplify data capturing and retrieving/reporting and to reduce paper works. One doctor responded *"I want to be able to get different reports from the system that are linked to TB care. For example, TB patients who are also on antiretroviral therapy (ART) or patients with TB and diabetes, or patients on TB care who suffered a certain drug reaction etc. and the like by age, sex and so on without a need to analyze one treatment card after another"*. Another responding doctor further added that, *'some people are on TB care but their data are missing....cannot be found anywhere'*. In addition to that, majority of the respondents showed a need for a TB module to be developed and integrated in Care2x rather than having a separate system for TB care.

Also, to access users' view on the importance of the module, health practitioners were asked to assess the extent to which integrated Care2x and TB module will reduce paper work, improve patients' data management, increase accuracy in creating reports and reduce running costs. The criteria for assessment was based on the scale of strongly disagree, disagree, neutral, agree, and strongly agree. Majority of respondents (50%) strongly agreed that the module will reduce paper work whereas (38.6%) of them agreed and the rest (11.4%) were neutral. Table 2 shows the results.

Table 2: Responses for integrated Care2x system and TB module will reduce paper work

Reduce Paper Work		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	5	11.4	11.4	11.4
	Agree	17	38.6	38.6	50.0
	Strongly Agree	22	50.0	50.0	100.0
	Total	44	100.0	100.0	

On improvement of patients' data management, 56.8% of the respondents strongly agreed and 43.2% agreed while none was neutral nor disagreed as shown in Table 3.

Table 3: Responses for integrated Care2x system and TB module will improve patient's data management

Improve Patients' Data Management		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	19	43.2	43.2	43.2
	Strongly Agree	25	56.8	56.8	100.0
	Total	44	100.0	100.0	

With the reported tediousness in generating reports which are error prone, again majority of the respondents (61.4%) strongly agreed that the module if developed will increase accuracy in creating reports. 36.4% agreed and the rest (2.3%) fell under neutral. Results from analysis are shown in Table 4.

Table 4: Responses for integrated Care2x system and TB module will increase accuracy in creating reports

Increase Accuracy in Creating Reports		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	1	2.3	2.3	2.3
	Agree	16	36.4	36.4	38.6
	Strongly Agree	27	61.4	61.4	100.0
	Total	44	100.0	100.0	

Respondents also showed a need to reduce costs by computerization of TB care. 63.6% strongly agreed that the module will reduce running costs while 34.1% agreed and 2.3% was neutral. Table 5 summarizes the results.

Table 5: Responses for integrated Care2x system and TB module will reduce running costs

Reduce Running Costs		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	1	2.3	2.3	2.3
	Agree	15	34.1	34.1	36.4
	Strongly Agree	28	63.6	63.6	100.0
	Total	44	100.0	100.0	

Respondents also indicated challenges with the current flow and system. The main reported challenges by majority of the respondents are unreliable power supply and loss of TB patients' files due to manual system. Also, the use of a long time in attending TB patients which is associated with lots of paper work. Other challenges are lack of enough knowledge on computer use. Furthermore,

majority of responding nursing officers reported that the nursing module in Care2x system lacks some functionalities required for charting patients' medication and nurses' activities, making their work not properly recorded and reported. In addition to that, one laboratory personnel indicated the current Care2x system has no room to capture TB culture results provided weekly by the laboratory.

3.2 Proposed Module Design

3.2.1 Conceptual Design

After analysis of both primary and secondary data, a framework for the TB module development and integration in Care2x was developed as shown in Figure 1.

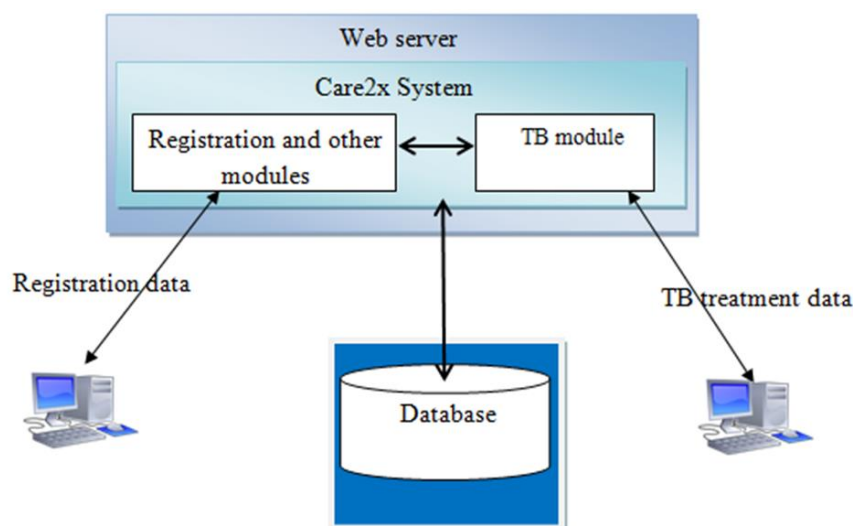


Figure 1: TB module development framework.

On the other hand, the main system Care2x already has its categories of users. The categories of users who will have access to the module are all care providers with assigned respective privileges. However, the privileges will be dynamically allocated for the module as per Care2x HMIS security approach. Figure 2 shows the proposed classes of users:

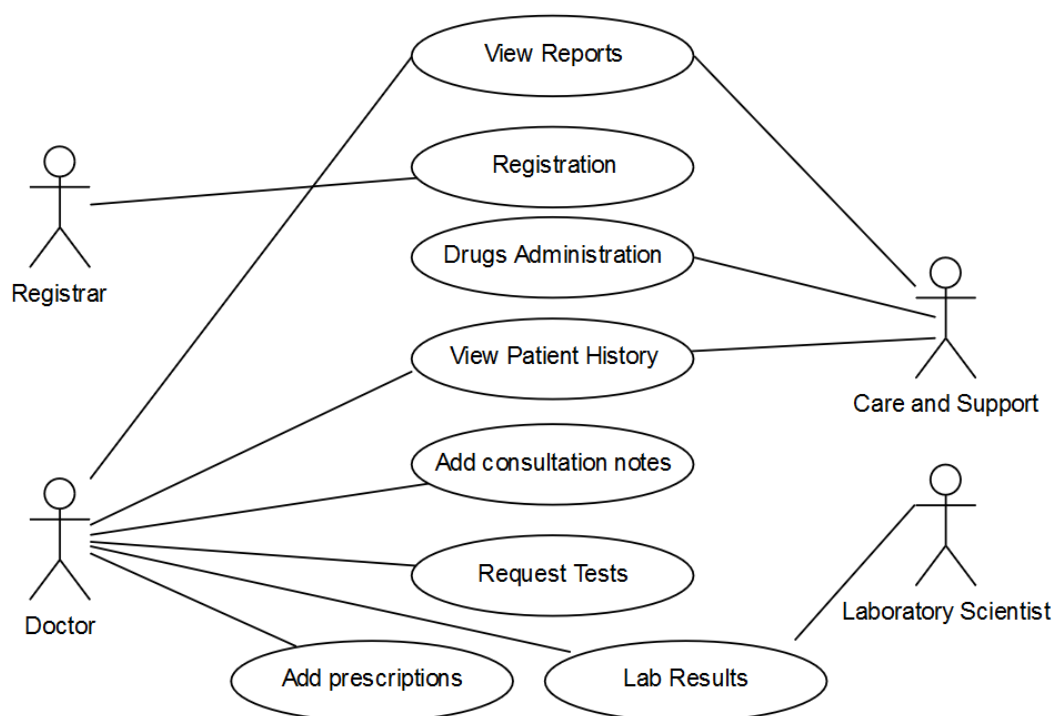


Figure 2: Use cases diagram for the initial design of a TB module in Care2x

3.2.2 Patients Workflow

Once the registration and admission send the patient to TB clinic/department in the main system, the list of patients in TB clinic gets updated and a user of the module can then access the patient from the module. The patient, if is first time visit, provides additional information which is recorded via the module. Figure 3 describes the designed patient flow with integrated TB module in Care2x that will not affect the existing flow.

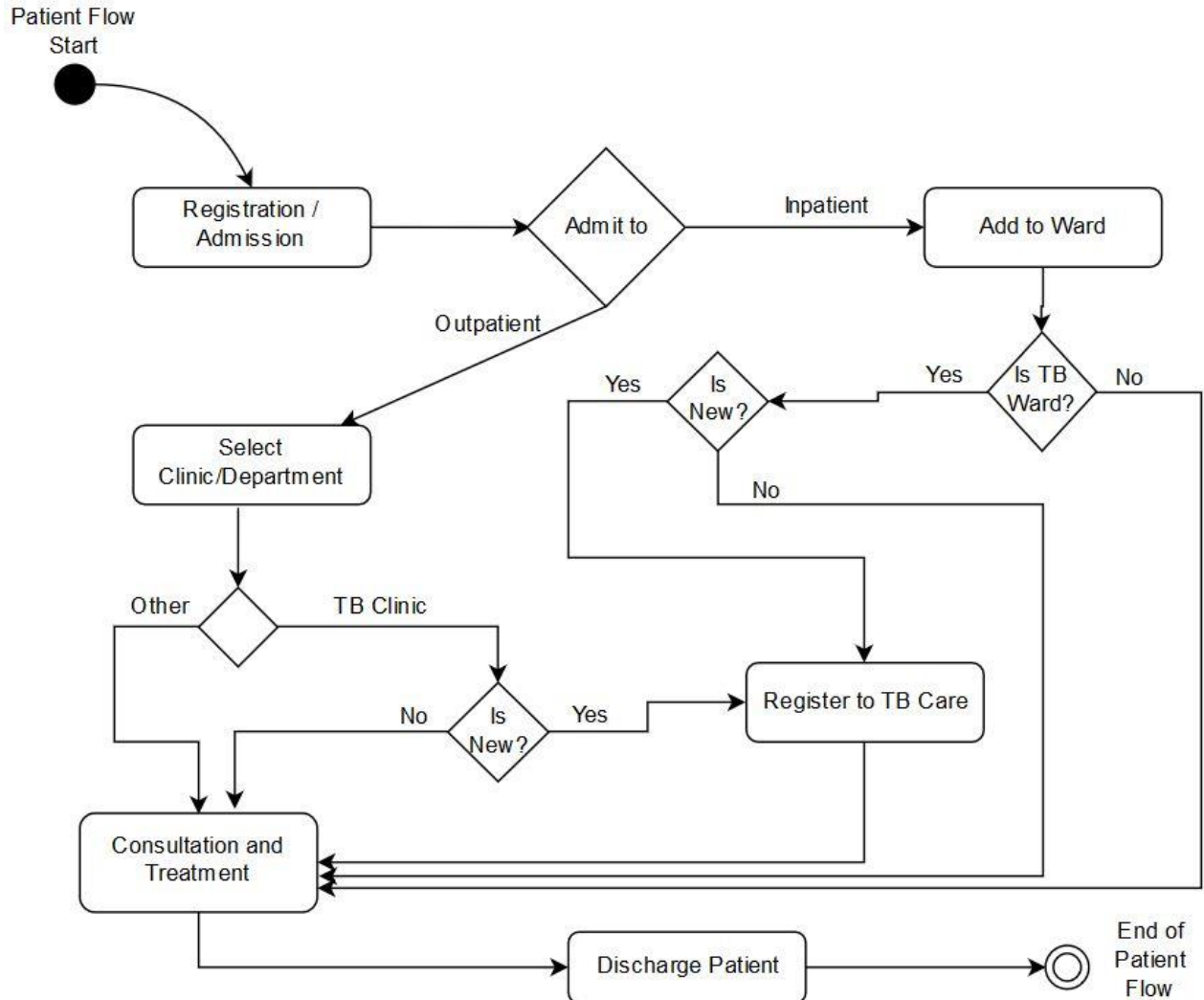


Figure 3: Proposed patients flow with integrated TB Module in Care2x

After accessing the patient through the module, the user fills in all other required clinical and progress information for the respective patient's visit. The user, most likely a doctor can issue prescriptions, set appointments and others from the TB module through linked respective modules. The required TB reports can then be generated from the Care2x system.

3.2.3 Database Design

To capture all the required TB data elements via a TB module, twenty-five (25) new tables have been added to Care2x database and four existing tables modified by adding new columns. The modified tables carry data about patients' visits, prescriptions, test requests and findings. Figure 4 describes the tables' relationships in an enhanced entity relationship (EER) model for the integrated TB module.

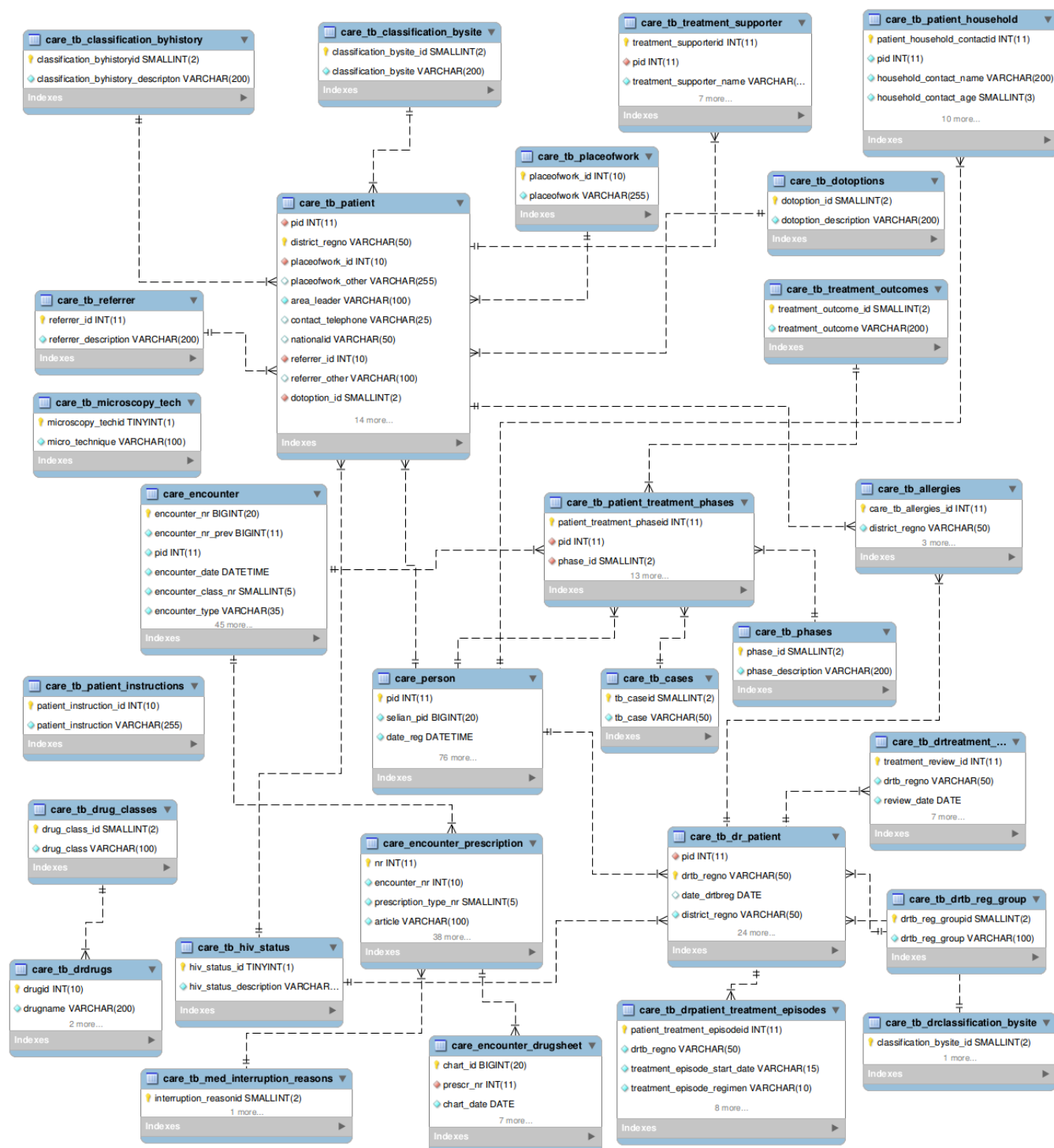


Figure 4: EER diagram for an integrated TB module in Care2x

3.3 Constraints

Since the system and the module are web based, following constraints apply on the operability of the module:

- Local Area Network (LAN) and Internet: for the user to access the system and module, he/she will need a connection to the server which can be a local server via LAN or an online server via internet for remote connection.
- Web Browser: The client computer/device will need a browser to access the system.

3.4 Assumptions and Dependencies

One assumption about the module is that it will not be able to operate on its own but will always use data from registration/admission module and data from other modules. The architecture of TB module will be based on the architecture of Care2x HMIS. The programming language that will be used is PHP, with HTML5, JavaScript and CSS. For interface design, Bootstrap will be employed to support mobile devices with low resolution. The care2x supported database server is MySQL, thus the module is also designed on the same.

4. Discussion and Future Perspectives

Health practitioners at KIDH showed a strong need for integration of patients' TB data with their corresponding other clinical data. Our aim is to computerize the TB care while having all the patients' data in one place. Despite several challenges, many respondents indicated that Care2x system has been helpful to the hospital. Therefore, it is suggested that a module be developed and integrated in Care2x. An evaluation study on the developed module will need also be conducted.

Furthermore, a mobile integration for TB care provision is invited to support home-based care and easing data collection on outreach clinics. Also, patients can be reminded of taking their medications, following their appointments and a lot more with this integration.

4.1 Limitations

The first limitation of this study is that it is focused on one health facility only. However, it is assumed that, since KIDH is a National designated facility for TB care, and the guidelines provided by the WHO and the ministry apply to all facilities, the results of this study can be applied to several other facilities that run Care2x HMIS in the country.

Another limitation is the length of questionnaires, especially the questionnaire for doctors which required many qualitative responses that led to some respondents to leave some questions unanswered.

5. Conclusion

Despite many implementations of generic e-health systems and systems to support TB care, it is observed that the systems are independent. Literature suggests that most TB e-health systems are purposely designed for TB surveillance only. However, findings of this study indicate that, an integration of all clinical and program specific patients' data is essential to maintain quality and complete data.

This study has therefore provided a design of an integrated module in Care2x HMIS to enhance integration of patients' data, improve delivery of health care to TB patients as well as timely and accurate reports generation as per WHO specifications.

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JEL Classification: I10, M15